(12) UK Patent Application (19) GB (11) 2 318 002 (13) A

(43) Date f A Publication 08.04.1998

(21) Application No 9620554.7

(22) Date of Filing 02.10.1996

(71) Applicant(s)
Melvyn Webster
Aston House, Little Lane, Loosley Row, PRINCES RISBOROUGH, Bucks, HP27 0NX, United Kingdom

(72) Inventor(s)
Melvyn Webster

(74) Agent and/or Address for Service
Chris J Tillbrook & Co
5 Old Rectory Close, Churchover, RUGBY, Warks, CV23 0EN, United Kingdom

(51) INT CL^6
H02H 3/33

(52) UK CL (Edition P)
H2K KFA K301 K452 K463 K771

(56) Documents Cited
GB 2211683 A **GB 2019677 A**

(58) Field of Search
UK CL (Edition P) **H2K KFA KHB KHK KJS**
INT CL^6 **H02H 1/00 1/04 3/00 3/16 3/33 3/347**
Online: EDOC, JAPIO, WPI

(54) **Earth leakage current sensor**

(57) A programmable sensing circuit 51 has a current imbalance sensor coil 55 and a line current sensor 59, each coupled to a microprocessor 58 by an analogue-to-digital converter 57,61. An actuator 62 opens switches 63, 64 in response to a signal from the microprocessor 58, which is connected to memories 65, 66. The circuit 51 may respond to changes in the level of leakage current independently of absolute value, or may trip only when an increase in leakage current does not coincide with an increase in load current, so that nuisance tripping is reduced.

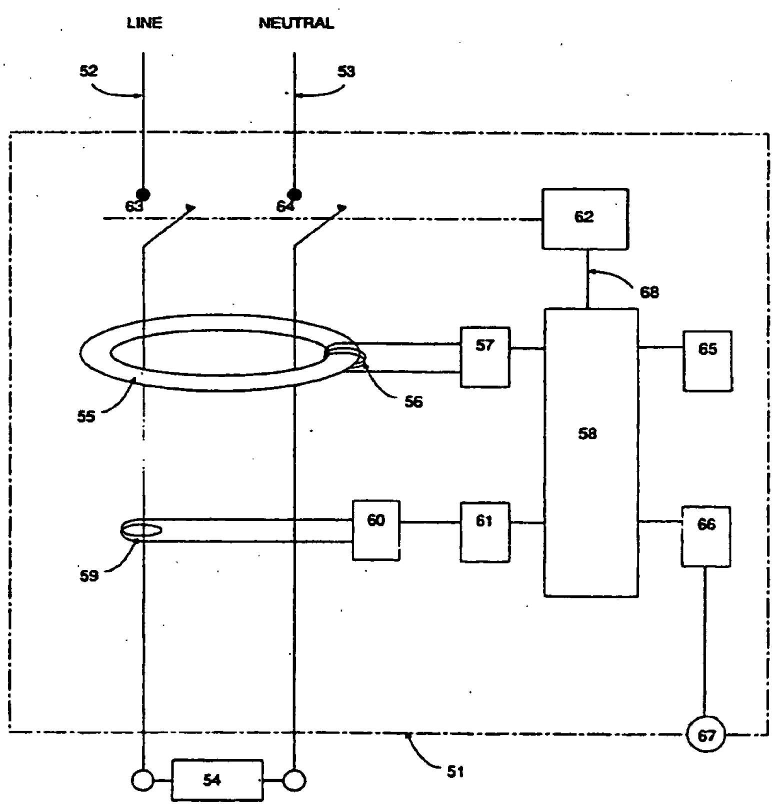


FIG 2

GB 2 318 002 A

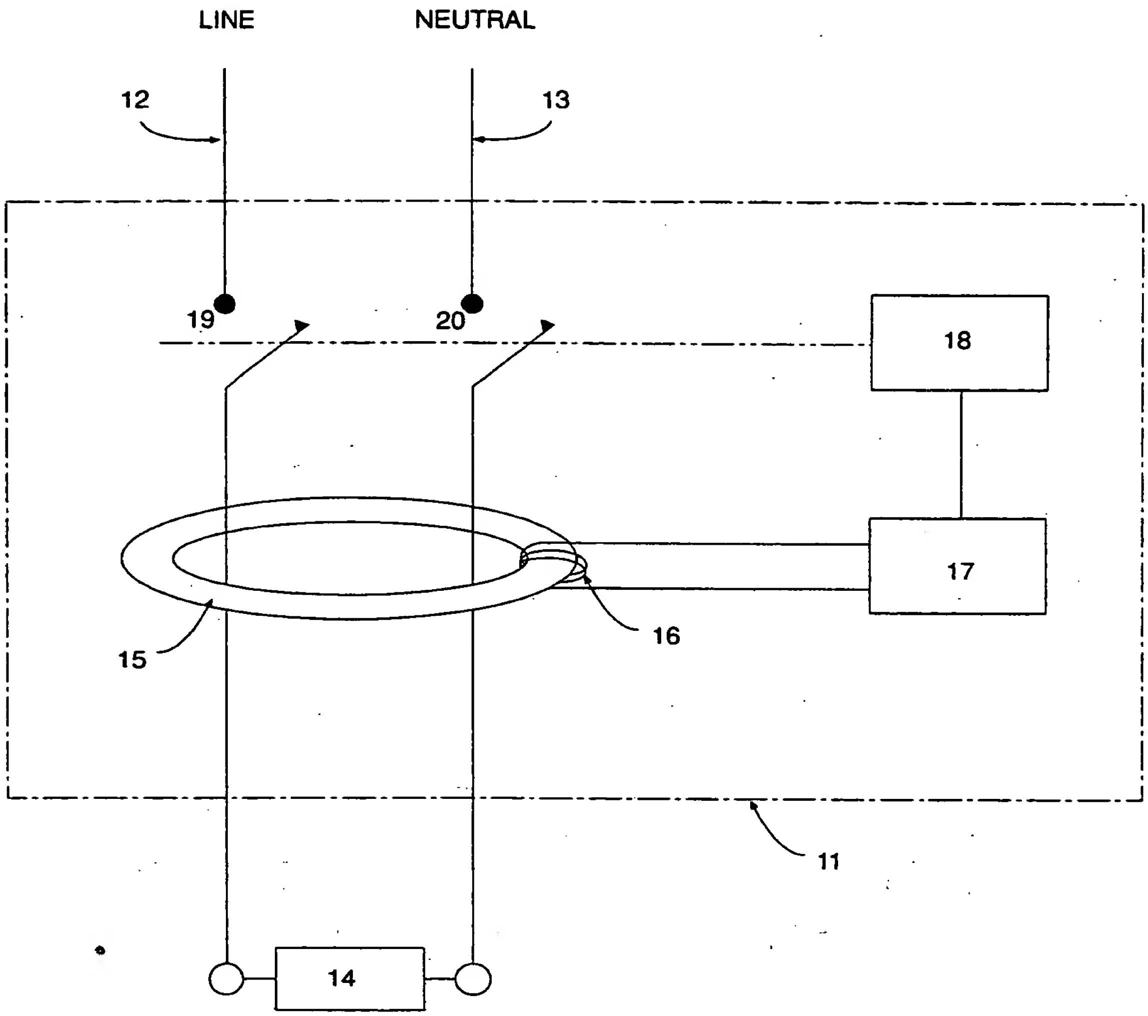


FIG 1

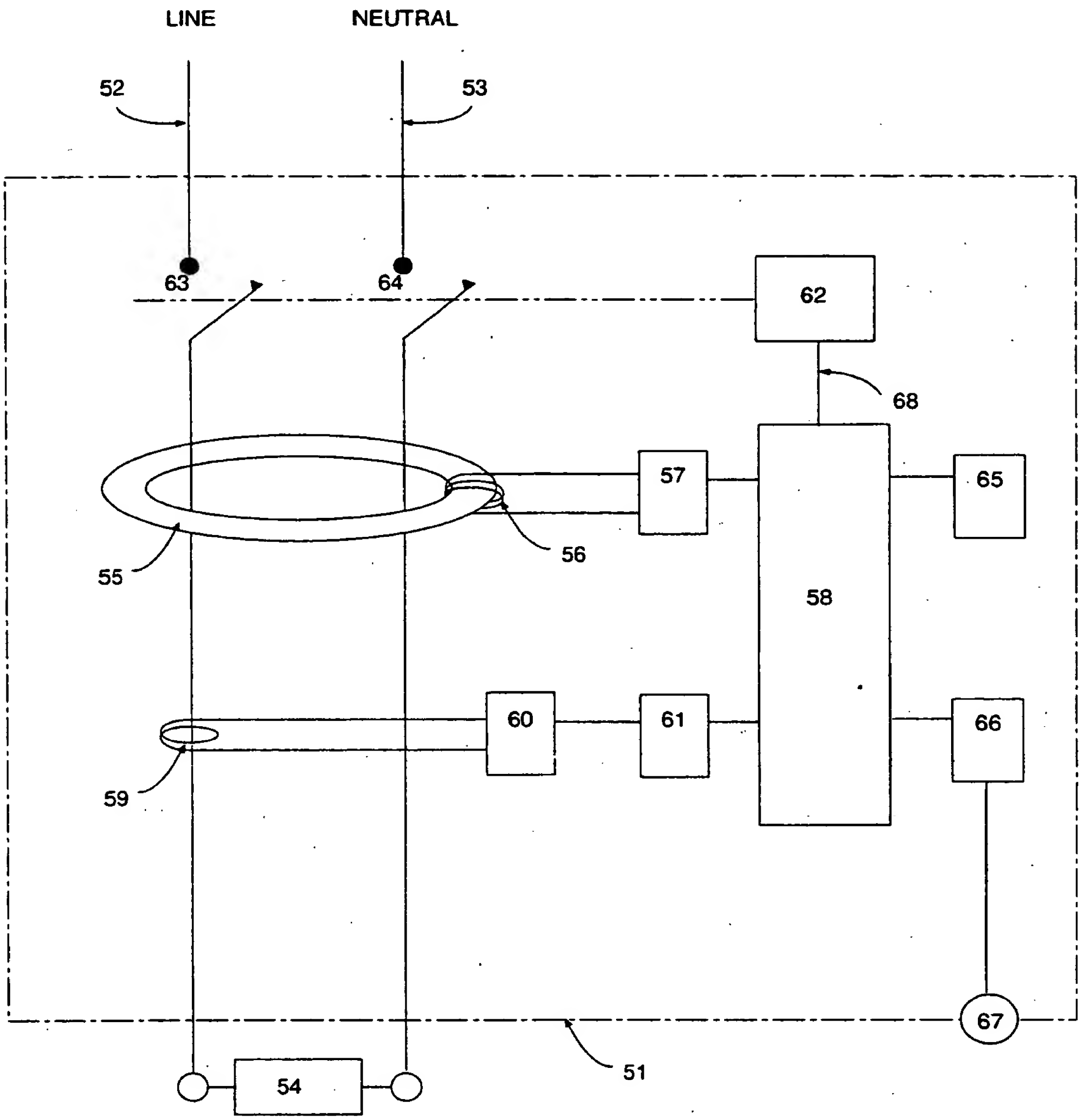


FIG 2

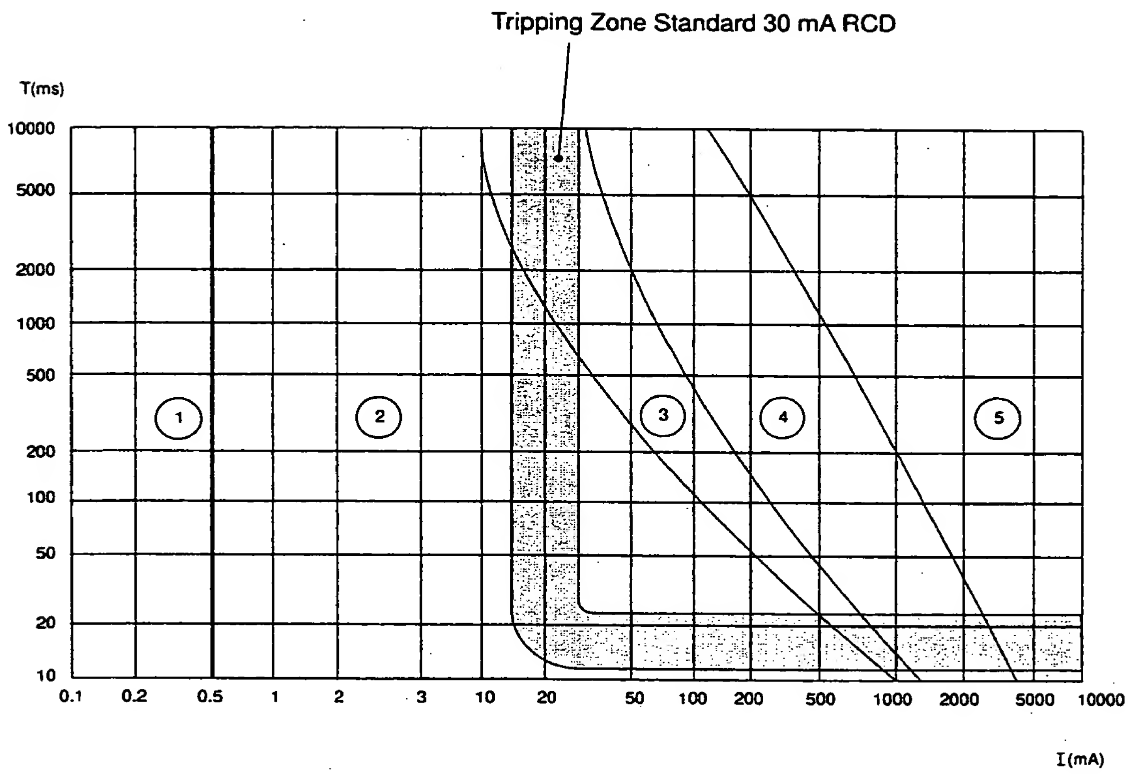
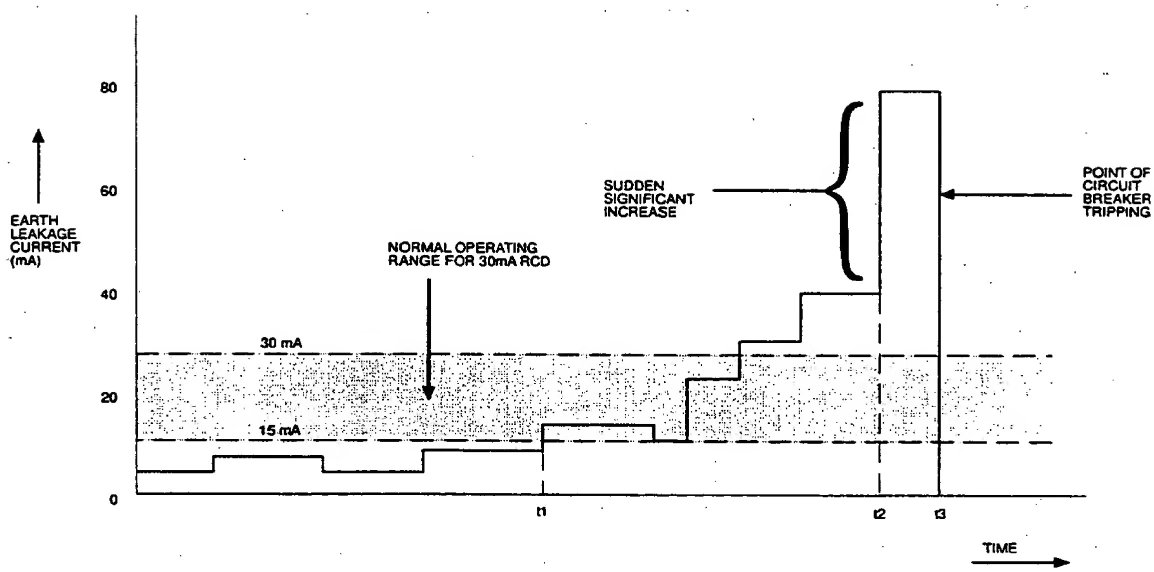
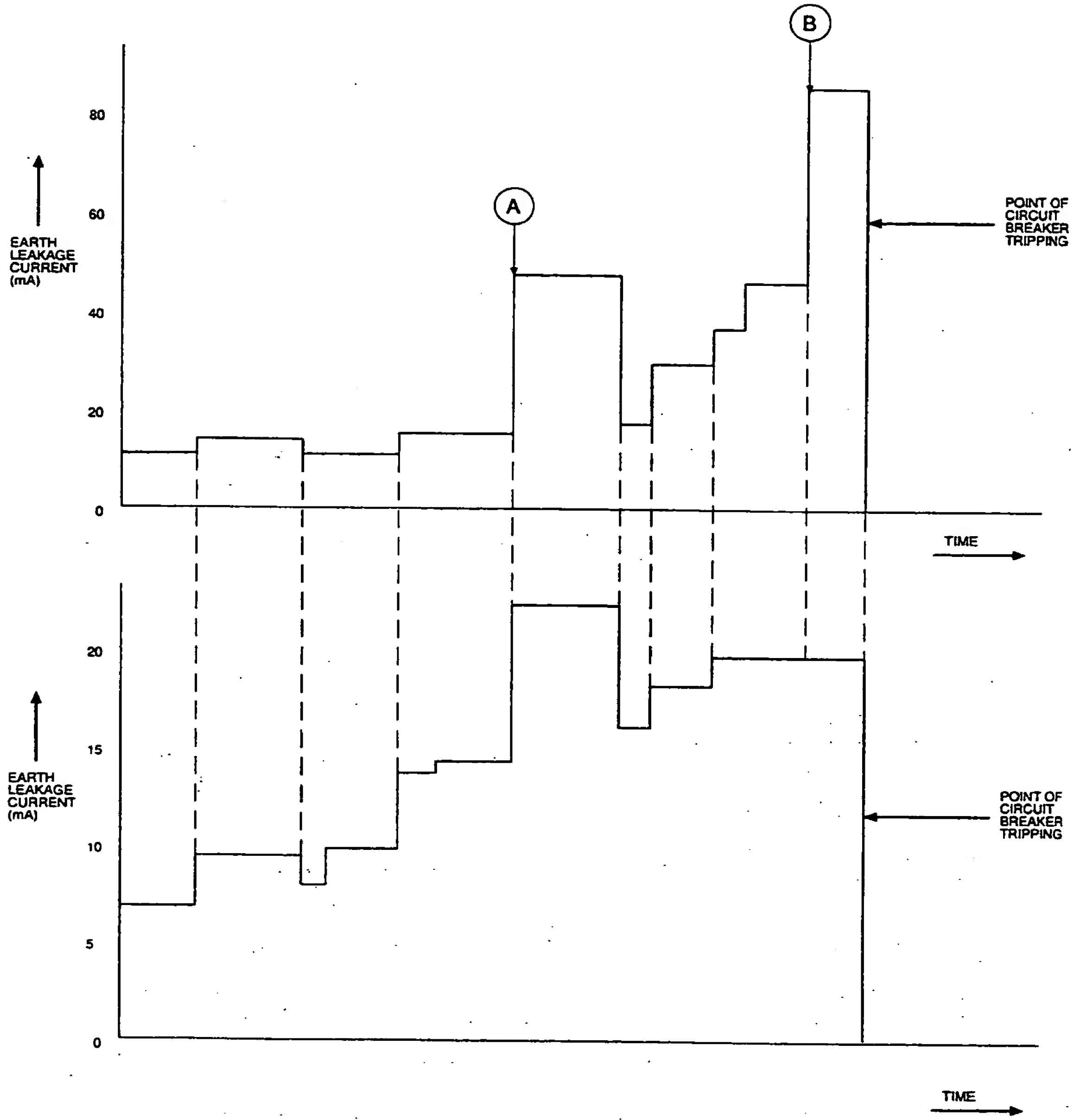

Tripping Zone Standard 30 mA RCD
T(ms)
10000
5000
2000
1000
500
200
100
50
20
10
1
2
3
4
5
0.1
0.2
0.5
1
2
3
10
20
50
100
200
500
1000
2000
5000
10000
I(mA)

FIG 3



80
60
40
20
0
EARTH LEAKAGE CURRENT (mA)
NORMAL OPERATING RANGE FOR 30mA RCD
30 mA
15 mA
SUDDEN SIGNIFICANT INCREASE
POINT OF CIRCUIT BREAKER TRIPPING
t1
t2
t3
TIME

FIG 4



80
60
40
20
0
EARTH LEAKAGE CURRENT (mA)
A
B
POINT OF CIRCUIT BREAKER TRIPPING
TIME
20
15
10
5
0
EARTH LEAKAGE CURRENT (mA)
POINT OF CIRCUIT BREAKER TRIPPING
TIME

FIG 5

'Leakag Tolerant' Fault Sensing

This invention relates to electrical load fault monitoring and the automated isolation from a power supply of loads with faults deemed 'unsafe'.

The various faults which may inhabit a load circuit are manifested in load current traits.

These may be broadly categorised as short circuit, excess or overload and (earth) leakage currents. Of these, leakage currents merit special consideration.

Leakage

The total load in a circuit is the accumulation of active loads and the effective loads represented by leakages inherent in all loads and ancillary supply circuitry.

The total leakage current is the sum of lesser leakage currents in individual load and circuit elements. As such it may represent too coarse a factor to monitor, whereas the individual leakage may be too small.

Some degree of minimal leakage is inherent in all loads and can be treated as a natural phenomenum, which does not necessarily represent a safety hazard nor require any corrective action.

In some loads, such as heating elements, leakage is more prominent and variable that in others.

However, if left unchecked beyond a certain threshold, leakage currents can allow hazardous voltages to arise in circuitry, load components or attendant earth return paths - and with which a consumer can come into contact.

Generally, these leakages are of a lesser order of magnitude - ie milliamps mA - in relation to load currents of several amps or tens of amps.

As such, leakage current variations can be obscured by fluctuations in load current.

It is therefore advantageous if leakage current can be monitored independently of load current - for example by monitoring the supply and return currents and making a differential evaluation, which represents the total leakage current.

Some aspects of the present invention are particularly concerned with the detection and isolation of latent load hazards, associated with 'earth leakage', whilst obviating spurious safety alerts and 'nuisance' tripping.

A wider aspect of the invention is the adaptation of fault sensing to dynamic load behaviour, for a more 'intelligent' and responsive safety reaction.

Shock

(UK) consumer power supply voltage in the range 220-240 V (volts) is a hazardous level for the human physiology and so provision is commonly made in consumer load circuitry to isolate the consumer from the consequences of electrical shock.

Typically, such (single phase) mains power is supplied to consumers through two supply lines, namely a live or so-called 'line' side - generally at the full supply voltage - and a neutral return - generally at zero voltage.

Earthing

In so-called PME (Protective Multiple Earth) systems, the neutral is also connected to earth - and no separate supply earth is provided.

At the consumer installation, earthing of the electrical supply and thus of individual appliances with an appliance earthing point connected thereto, is effected by achieving an equipotential zone, within which all earthed metal work is deemed to be at zero potential.

The intention is that leakages arising from insulation faults run to ground - allowing a level of fault current which can be detected as over-current and trigger operation of circuit protection equipment.

At best, however, this can provide some degree of protection inside a building - but not outside, where the building internalised earthing system is ineffectual.

A poor fall-back earthing path can allow a faulty appliance to remain 'live' to external contact, albeit with a slight leakage to earth - without generating sufficient fault current to blow a fuse in the supply line or to trip an over-current circuit breaker.

This condition is know as 'indirect' contact - whereby metal work becomes live and so a hazard if touched.

Direct contact, whereby a person touches a 'live' conductor, can also cause currents at fatal levels - but insufficient for over-current protectors to operate.

RCD's

To address such conditions, so-called RCD (Residual Current Devices) have been developed - both on the mains supply and at the (plug and socket) connection to individual appliances. Three-phase versions are also available.

The sensitivity of such RCD devices reflects their situation and in particular the 'downstream' load monitored.

Indeed in some jurisdictions RCD provision is compulsory on all socket outlet circuits.

RCD current sensing is generally through a magnetic core surrounding the supply line and neutral conductors and with a sensing coil wound around it.

Electromagnetic flux is induced in the core by both line and neutral conductors - but in opposite senses.

In a 'healthy' circuit, the line and neutral currents are equal and opposite and the resultant electromagnetic flux in the core is zero, with no net induced current.

Any disparity or imbalance between the line and neutral arising from earth leakage causes a small net flux in the coil, proportional to the out-of-balance current.

This resultant flux induces a current in the sensing coil around the magnetic core, and which in turn trips a circuit breaker - dependent on the leakage current-time characteristic.

In the case of three phase RCD's, the three line conductors and the neutral conductor pass through the magnetic core and out-of-phase leakage is detected in the same manner as for single phase devices.

Minor leakages can be tolerated, as part of normal load and attendant wiring 'loss' characteristics.

If a person touches part of a live circuit, the total demand or line current will not increase significantly in amperage terms, so any over-current protection (such as fusing) will remain inoperative and ineffective in shock-prevention.

However, the attendant leakage current through the body, typically between 80mA and 240mA, can be detected as a residual current and used independently of current overload fusing to trigger supply cut-off or isolation.

Thus a permitted leakage threshold of some 30mA may be deemed sufficient for shock prevention - ie avoidance of triggering heart fibrillation conditions.

Aside from shock hazard, another prime safety consideration is fire risk.

Fire

Fire can be initiated in buildings by localised overheating and can also arise from earth leakage faults, allowing leakage currents through or in thermal contact with flammable building fabric, such as timber joists and rafters.

Leakage currents as low as 500mA can generate incandescence in high resistance paths and thus trigger fires.

A permitted leakage threshold of some 300mA affords 'loose' fire prevention and provides an earthing facility where earthing is a problem, thus allowing transient faults to dissipate, as a preferred solution.

On the other hand some 100mA could provide adequate protection against fire and some shock protection, dependent on the fault characteristics and physiological conditions.

However, RCD devices have not hitherto been regarded as universally applicable, because of their vulnerability to unacceptable spurious tripping through natural leakage. Tripping when there is no hazard present is known as 'nuisance tripping'.

Such spurious triggering and power supply cut-off can itself represent a hazard, for example if lighting is failed at night by disconnection triggered from an un-related fault.

Thus RCD's with inadequate sensitivity are sometimes used - *or are omitted altogether*, so providing no direct shock protection.

Standard tripping current performance 'maps' are issued by regulatory standards authorities to define graphically, albeit somewhat arbitrarily, the 'compliance' required of an RCD safety device.

One such map is of earth leakage current versus time elapsed or duration of the leakage.

The consequent characteristic curve is a form of hyperbolic 'S'- shape, over a tolerant to intolerant spectrum - with higher leakage currents being admitted for shorter durations and lower leakage currents for higher durations.

Any given leakage current has an attendant time allowance before tripping.

This is sometimes known as a 'life' curve, since it effectively designates a threshold - on one side of which no fatally hazardous current and time combination is likely to arise - and on the other side of which is an operational zone of increasing danger.

Conventional RCD's are generally calibrated for one time current characteristic only.

An object of some aspects of the invention is to *reduce nuisance tripping, whilst preserving life saving protection.*

According to one aspect of the invention
a load safety device monitors
the fluctuation of leakage current in a circuit load
and initiates power supply isolation,
in relation to abrupt leakage level transitions,
independently of absolute leakage levels,
and which transitions represent a human physiological contact (load)
with part of the load circuit;
for enhanced leakage tolerance,
without undermining shock prevention.

According to another aspect of the invention
a load safety device monitors <u>both</u>

a load (consumption) current and an earth leakage current, to trip a circuit breaker connected in the supply line and operative, upon departure or transition of the load and leakage currents from predetermined criteria, to isolate the load from an electrical power supply.

According to a further aspect of the invention a programmable earth leakage current detector is set to monitor fluctuations in leakage over time and to recognise the size of transitions from one leakage threshold to another, independently of the absolute leakage level, in order to determine an unsafe leakage and to instigate safety control action, such as tripping of a circuit breaker.

Such an unsafe leakage transition may represent contact of a human body with a 'live' part of the circuit and the formation of an earth leakage path through the body.

Leakage may be monitored in conjunction with load current, in order to recognise a '*coincident transition*' in load and leakage attendant switching on, or enabling, of a known load characteristic.

Such a coincident transition indicates that the leakage is related to the load switched on.

Current monitoring may be implemented through a computer, such as a microprocessor, with discrete inputs representing load and leakage currents and a memory of allowable load performance criteria.

Overall, such a device could provide a digitally operated Residual Current Device (RCD), offering dual protection against electric shock and fires caused by earth leakage currents - *and yet with less susceptibility to nuisance tripping than a conventional RCD, allowing it to be more widely installed.*

As earth leakage situations occur in all parts of the circuit and load, the aggregate sum of leakage currents can exceed a conventional RCD device setting and tripping can occur - *even though there is no single one occurrence which would by itself warrant tripping on shock or fire prevention grounds.*

The present invention allows the overall level of earth leakage to rise above normal operating levels, but seeks to protect against individual increases of a significant magnitude and nature.

According to yet another aspect of the invention a fault sensing and isolation safety device, for an (alternating current) electrical power supply,

with a supply line and a return line,
comprises
a load current sensor and
a residual current sensor,
as inputs to a comparator,
and as another input
one or more generated reference signals
representing individual prescribed allowable load spectra
with known performance profiles or characteristics;
a programmable reference signal generator,
a memory store for storing reference signals,
corresponding to predetermined load profiles
the memory contents being accessible through said other comparator input,
a sensing circuit responsive to said comparator output,
representing any divergence or disconformity
between allowable and actual load profile,
a circuit breaker for isolating, by electromechanical disconnection,
the supply from the load,
an actuator for the circuit breaker
the sensor output controlling the actuator.

According to a further aspect of the invention,
a device for mapping
individual electrical load characteristics
is used to construct an active database
of load spectra,
which is in turn used as a reference portfolio
for comparision with actual load characteristics actively encountered,
thereby incorporating self-learning techniques,
to provide an intelligent flexible fault trigger
for load disconnection.

In that regard, the device may perform as a universal current monitor, which can be adapted, for example pre-programmed, to address particular performance criteria.

Thus, the device could interface generally between a circuit to be monitored, even using existing sensors, and an (existing) control facility for that circuit.

Moreover, the device could allow sophisticated analysis of load characteristics and actual performance operationally and in particular a refined physiological curve of leakage current through the body and of body (in)tolerance to electrical shock.

It is envisaged that the device could thereby recognise human body contact at relatively low leakage levels and initiate cut-off with a higher anticipatory safety margin - that is <u>before</u> dangerous leakage current levels arose.

As such, the device could meet - and supplement - prevailing performance standards for safety trips, easing its electrical approval and commercial adoption.

In the longer term the device could justify its own performance mapping, superseding that for conventional devices.

According to another aspect of the invention a device for dual monitoring, of line and leakage currents, in loads on an electrical power supply, is structured as a discrete module, which can be integrated with existing interrupt or cut-off or isolator switch mechanisms, and which can updated programmably or by substitution, the device providing greater intelligence for interpreting load characteristics and initiating action only when appropriate, thus obviating nuisance tripping.

According to yet another aspect of the invention, an interface device between a power supply load sensor and isolator, comprises a programmable interpreter, and a memory for storing various load characteristics, and addressing both excess and leakage current scenarios.

The device could maintain a base line performance of conventional safety devices, but provide a supplementary tier of sensitivity.

Alternatively, the device could be used to substitute for or in conjunction with conventional devices.

In the latter case, a conventional device could be temporarily over-ridden or disabled, with a fail-safe return into circuit, to allow a greater fluctuation in safe leakage than the conventional device on its own would allow, without spurious or nuisance tripping.

Device responsiveness through a fast operational internal clock frequency, with attendant brief sampling periods, would enable the device to respond rapidly to unsafe leakage transitions.

Such a device could be programmed for ongoing updating and can incorporate a participative learning facility to make more mature judgements upon acceptable loads.

In particular, variations in 'service' leakage could be accommodated, without merely resorting to gross overall de-sensitisation.

In practice it is envisaged that such active intelligent load profiling could be accumulated digitally, allowing larger leakages, of say, 100/150mA, provided satisfying bona fide recognised leakage criteria - ie no undue leakage transitions.

Moreover, sudden imposition of a human load, associated with electrical shock contact, could be recognised and the attendant leakage current 'step' - typically at some 80mA greater than other leakage currents of some 30mA - recognised at an early stage and interrupted.

More broadly, other step loads, that is loads with initial switch-on high current transitions or transient peaks, could still be recognised.

Ongoing leakages could be admitted if they represent an inherent load characteristic.

Computation could be performed by a dedicated single-chip programmable microprocessor.

Control and re-programming could be remotely, for example through a radio or infra-red link.

Aside from stand-alone format, such devices could also be incorporated into existing safety devices, for example RCD's, to trigger existing cut-off or isolator switches by controlling the same relays.

The consistency and reliability of the supply provision is thus freed from interruption by loading vagaries.

This might be key to their more rapid and widespread adoption.

There now follows a description of some particular embodiments of the invention, by way of example only, with reference to the accompanying diagrammatic and block schematic drawings, in which:

Figure 1 shows a conventional known RCD power supply fault detector and circuit breaker;

Figure 2 shows a power supply fault detector and circuit breaker according to the invention;

Figure 3 shows graphically the effect over time of (alternating) current upon human physiology;

Figure 4 shows graphically pulsed sampling of earth leakage current vs time; and

Figure 5 shows graphically pulsed sampling of both earth leakage and load currents vs time.

Referring to the drawings, in Figure 1 a conventional RCD 11 is connected to an alternating current mains power supply line 12 and neutral 13, 'protecting' a remote load 14.

Both conductors pass through a magnetic core 15, with a sensor coil 16 wound around

it to detect any residual magnetic flux. A single phase arrangement is shown for clarity.

The line and neutral currents in a 'healthy' circuit (ie one free of leakage current faults) are equal and opposite - with no residual magnetic flux induced in the core.

Any line-neutral imbalance or difference caused by leakage induces a (net) residual magnetic flux proportional to the current imbalance and this is detected by the coil 16, producing a sensing current - again proportional to the imbalance.

The sensing current operates a solenoid relay device 17, which triggers a circuit breaker 18 at a predetermined level of current imbalance.

The circuit breaker opens switch poles at 19 and 20, disconnecting the power supply from the faulty circuit or load 14.

Figure 2 shows a sensor safety device 51 in accordance with the invention and having some commonality in layout and disposition with the conventional RCD of Figure 1. Again a single phase arrangement is shown for clarity.

More specifically, an alternating current mains power supply line 52 and neutral 53 are connected to a load circuit 54.

The line and neutral conductors 52, 53 pass through a magnetic core 55, with a sensor coil 56 wound around it to detect any residual magnetic flux.

Current induced by any imbalance (leakage) in line and neutral current, and hence in the induced magnetic flux in the core 55, is converted to a digital level by an analogue/digital convertor 57, providing a digital input to a microcontroller or microprocessor 58.

A further current sensing device in the form of a coil 59 detects current flow in the line conductor only. The output from the coil 59 is rectified by a diode arrangement 60 entering an analogue/digital converter 61 to provide a second digital input to the microcontroller 58.

The microcontroller 58 is thus capable of addressing <u>both</u> the gross line current load and the leakage current in arriving at a control decision.

A program memory 65 of load profiles or performance algorithms for deriving reactions to given criteria is updatable through the microprocessor 58 and an external interface 67 - through which performance data can also be down-loaded.

Past operational performance can also be loaded into and accessed from a temporary or flash memory 66.

The microprocessor output 68 controls an actuator 62 opening switch poles at 63 and 64 disconnecting the power supply from the faulty circuit load 54.

Figure 3 shows a cluster of standard performance reference curves, under regulation

IEC 479, for the effect over time of alternating current at cycle frequencies of 15-100 Hz upon the human body.

In Zone 1 to the far left, at low currents, there is usually no reaction.

Moving progressively to higher currents, in Zone 2 there is usually no dangerous effect.

At still higher currents in Zone 3, there is usually no risk of heartbeat rhythm irregularity or fibrillation.

Beyond this, in Zone 4, there is some (less than 50%) risk of heartbeat disturbance or fibrillation.

Eventually, in Zone 5 there is a marked risk (over 50% probability) of heart fibrillation (even heart failure).

The boundary curves differentiating Zones 2 through 5 show a marked steeping of sensitivity at higher currents - representing lower tolerance to higher current and thus the need for isolation more rapidly to reduce the exposure time.

In that regard, the shaded zone represents a tripping band for a standard 30mA RCD.

Figure 4 depicts pulsed load sampling according to the invention, in the monitoring of leakage current fluctuation, and in particular a typical earth leakage current profile and attendant tripping to obviate a possible shock hazard.

Thus the microprocessor 58 detects a marked increase in earth leakage current at time instant t2 - and continues to monitor leakage current increase with time, eventually tripping at instant t3. The latter represents a time/current hazard under IEC 479.

Between t1 and t2, the microprocessor 58 allows leakage to continue, despite being within the normal operating range of a conventional 30mA RCD, as no danger is detected in the form of a sudden significant increase 'within' the constraints of IEC479.

Figure 5 depicts graphically a development of pulsed load sampling according to the invention, with monitoring simultaneously of <u>both</u> leakage and load current fluctuation - plotted one above the other on a common timebase scale.

Thus, an (upward) step in earth leakage current is noted by the microprocessor 58 as coincident with an (upward) step in load current at instant 'A'.

A significant increase in earth leakage current is 'tolerated' by the microprocessor 58, <u>without</u> instigating circuit-breaker tripping, as it is coincident with a step in load current.

This indicates that the leakage is likely to relate to the load - and <u>not</u> to a person touching an exposed live part.

At instant 'B', leakage occurs at a time when <u>no</u> load increase occurs and the microprocessor 58 therefore continues to monitor the leakage in relation IEC 479

standards - instigating an isolator trip if in the pr scribed danger zones.

Generally, Figures 4 and 5 show the effect of current changes, irrespective of the overall level of current leakage at the time of an event.

Such a 'floating' response to change allows the earth leakage to rise to levels above those which would trigger a conventional RCD - unless a supplementary monitor determines a load characteristic of a human body touching an exposed live conducting part of the circuit.

The microprocessor 58 of the invention has a high clock frequency or brief repeated operational cycle and can thus monitor rapid change in earth leakage current and respond by tripping the circuit breaker if any of the shock danger zones of Figure 3 are entered.

Similarly, other load conditions could be pre-programmed for recognition and corrective (isolation) action.

For example, a high overall load or leakage current level or a load/leakage characteristic representing an electrical fire arising from leakage could be recognised.

Overall, earth leakage is assumed dangerous only when it is concentrated in one location - for example, when an electric shock occurs, or at a point where a fire may start due to the leakage.

Leakage disseminated throughout a circuit and its loads may not necessarily be inherently dangerous - although high circulating currents should not be tolerated.

As the microprocessor operational rate is many times faster that the time period required to clear a potentially serious shock condition, the microprocessor can be programmed to identify load characteristics which would represent a personal shock.

The microprocessor control program can monitor changes in load current simultaneously with leakage current - and so accommodate increases in leakage current that are instantly accompanied by load current increases, on the basis that the increase in the leakage current can be reasonably expected to be caused by the load, provided always that the load current exceeds the leakage current (Fig 5).

This principle allows the microprocessor programme extra scope for selectivity to achieve less nuisance tripping.

Even significant levels of earth leakage changes can be accommodated without tripping, if the microprocessor 58 can relate the leakage to a new load which has just been switched into the circuit.

Overall, it remains critical that earthing and bonding, in accordance with the IEE Wiring Regulations, are still applied rigorously to circuits.

A dangerous situation could occur if a fault was present on an unearthed, or badly

earthed item, eg a metal table lamp with a broken earth conductor.

A person switching on the lamp might not be protected, in this instance, any better that a circuit without an RCD, as the coincident load and leakage currents would appear to be acceptable.

Further refinement could address and eliminate this problem, by either incorporating a self-learning feature into the programme (a supplementary operating principle), or by investigating, identifying and modelling the detailed shape and characteristic of a human electric shock, which may remain detectable, despite the background presence of other leakage.

However, if the table lamp was operating <u>before</u> it was touched, the device would trip correctly, because the load and leakage due to shock would <u>not</u> then be coincident.

As a safety default, the device could revert to an operating principle to determine when tripping should be instigated.

The concept of coincident load and leakage increase (and decrease) could still be used to determine a safe overall high limit leakage level for the circuit, by aggregating the leakages which occurred in a bona-fide manner - ie those related to the application of a load.

Self-learning principles could be incorporated into the microprocessor programme.

The device could be switched to 'test or learning mode', to allow a period when all likely devices on the circuit would be switched on and off, allowing the computer to memorise the characteristic of each load for future comparison.

Any new loads which were introduced to the circuit at a later date could be incorporated during the 'test mode' at any time. The 'test mode' could incorporate a timed reset, to ensure that it was not left on.

The microprocessor unit could incorporate the means to be reprogrammed 'in situ' as improvements in programming became available.

Similarly, manufacturers could receive the unit unprogrammed, allowing them to incorporate their own programming developments.

For ease of reference, there follows a component list:

(Figure 1)

11	(conventional) Residual Current Device (RCD)
12	line or supply current conductor
13	neutral or return current conductor
14	external load circuit
15	magnetic core (toroid)
16	residual flux sensor (coil)
17	solenoid relay device
18	circuit breaker actuator
19	circuit breaker switch pole (line)
20	circuit breaker switch pole (neutral)

(Figure 2)

51	load sensor/differential current device
52	line or supply current conductor
53	neutral or return current conductor
54	external load circuit
55	magnetic core (toroid)
56	residual flux sensor coil
57	analogue/digital convertor
58	microprocessor
59	load monitoring coil
60	rectifying diode arrangement
61	analogue/digital convertor
62	circuit breaker actuator
63	circuit breaker switch pole (line)
64	circuit breaker switch pole (neutral)
65	programme memory store
66	programmable module
67	external interface for programming
68	output from microprocessor

Claims

1.

A load safety device operable to monitor the floating transition of leakage current in a circuit load and to initiate safety control action, such as power supply isolation, independently of absolute leakage levels, upon abrupt leakage level transitions, representing a human physiological contact load with part of the load circuit, whereby to accommodate greater leakage tolerance, without undermining shock prevention.

2.

A load safety device operable to monitor both a load (consumption) current and an earth leakage current, and to trip a circuit breaker connected in the supply and operative, upon departure or transition of the load and leakage current from predetermined criteria, [with particular reference to the coincident or non-coincident occurrence of changes in load current and leakage current], whereby to identify a potential human shock condition and to determine an acceptable absolute leakage current level based on acceptable leakages inherent in the loads applied to the circuit.

3.

A programmable earth leakage current detector set to monitor fluctuations in leakage over time and to recognise the size of transitions from one leakage threshold to another, independently of the absolute leakage, in order to determine an unsafe leakage and to instigate safety control action, such as tripping of a power supply isolator switch.

4.

An electrical load sensing device (51)

comprising a magnetic core (55) and residual flux sensor coil (56) on supply and return current paths (52, 53) of a power supply and a load (54) connected thereto producing a signal via an analogue/digital convertor (57) representing a leakage current as an input to a microprocessor (58), a load reference store (65) for storing allowable load characteristics, a comparator programme within the microprocessor (58) for comparing actual leakage current with an allowable load leakage characteristic and producing a control signal (68) for a supply circuit breaker (62).

5.

An electrical load sensing device (51) comprising a current sensor (57) on supply and return current paths (52, 53) between a power supply and a load (54) connected thereto, a load reference store (65), a reference comparator (58), for comparing an actual load leakage current with a corresponding load reference and prescribed current safety threshold stored in the load reference store, an actuator (62) for responding to the findings of the reference comparator and operative to trigger isolator switch poles (63, 64) to isolate from the supply loads departing from prescribed performance criteria.

6.

A load sensor, as claimed in either of the preceding claims, including a (programmable) microprocessor (66) to effect a comparator function and to provide supplementary interpretative capability of actual operating loads in relation to predetermined operational safety criteria.

7.

A load sensor, as claimed in any of the preceding claims, including an interpreter capable of updating its understanding of and reaction to actual loads monitored on the basis of past operating experience.

8.

A load sensor, as claimed in any of the preceding claims, including an interface (67) for updating a reference store (65) and operational program by external input of a load portfolio and for down-loading actual performance data.

9.

A load sensor, as claimed in any of the preceding claims, including a computation engine with a pattern recognition facility embedded in an analytical algorithm, for projecting outcomes and eventualities, should load and leakage current behaviour patterns be allowed to continue unchecked, and for intervening accordingly to direct actuator control of power supply isolation.

10.

A load sensor, as claimed in any of the preceding claims, including a master long term memory (65, 66) of loads and current fault conditions encountered, used as a performance adjustment factor in initiating supply isolation.

11.

A load sensor,
as claimed in any of the preceding claims, including a fuzzy logic operational profile or an inference engine or expert (learning) system,
or artificial intelligence for predictive event simulation.

12.

A load sensor, substantially as hereinbefore described, with reference to, and as shown in, Figures 2, 4 and 5 of the accompanying drawings.

13.

A load sensor,
as claimed in any of the preceding claims,
structured as an add-on module for an existing circuit breaker, to supplement and enhance the performance capabilities thereof, but without necessarily undermining existing safety tripping thresholds.

14.

A power supply consumer's unit, incorporating a load sensor as claimed in any of the preceding claims.

15.

A power supply or power socket outlet, incorporating a load sensor, as claimed in any of the preceding claims.

The Patent Office

18

Application No: GB 9620554.7
Claims searched: 1 and 3

Examiner: David Brunt
Date of search: 27 January 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H2K (KFA, KHB, KHK, KJS)

Int Cl (Ed.6): H02H (1/00, 1/04, 3/00, 3/16, 3/33, 3/347)

Other: Online: EDOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2211683 A	(CHEN) see page 4 lines 1-12 and page 8 lines 15-30	1 & 3
X	GB 2019677 A	(WESTINGHOUSE) see page 2 line 126 to page 3 line 3	1 & 3

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.